Virtual Research Environments supporting sustainability of global fisheries

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Introduction

Under the wider umbrella of the **European Open Science Cloud (EOSC),** 'The Future of Seas and Oceans Flagship Initiative', aims for the development of a thematic Marine EOSC serving the Blue Economy, Marine Environment and Marine Knowledge agendas. The Blue-Cloud project is a broad collaboration that builds this cloud, and the Food and Agriculture Organization of the UN (FAO) is using Virtual Research Environments (VREs) in two Blue-Cloud demonstrators; one for fisheries, one for aquaculture.

In the 2030 Agenda for Sustainable Development, 193 States pledged to ensure that "no one will be left behind" to achieve the Sustainable Development Goals (SDGs). For SDG Goal 14 "Life below water", FAO aims to support data sharing, data analysis and data dissemination with Blue-Cloud VREs, and 3 example VREs supporting these steps for the SDG indicator 14.4.1 'Proportion of fish stocks within biologically sustainable levels' will be introduced.

Tuna Atlas VRE; a cloud enabled database and OGC compliant Spatial Data Infrastructure

The Global Tuna Atlas VRE is a tool to integrate and analyse public domain fishery statistical data from various tuna Regional Fisheries Management Organizations. Data include catches and fishing efforts and size frequencies of the species managed by the five tuna RFMOs. It was developed with co-funding from H2020, FAO and IRD, and its strength is an ISO/OGC compliant spatial data infrastructure in the D4Science / Blue-Cloud. This ensures high reliability, re-usability and sustainability, and similar cases requiring the management of spatial data can quickly establish core services. Enabling these services is made possible by open source tools such as *geoflow*[1], a R package for managing and automating (meta)data publication workflows, and *OpenFairViewer*[2]; a re-usable map visualization web component, based on international standards (ISO, OGC) supporting FAIR data implementation, and offering standard data access and sharing fully driven by metadata. For instance, these tools will allow other Blue-Cloud VREs such as the GRSF to publish and disseminate information about stocks and fisheries.

In H2020 Blue-cloud, the Tuna Atlas will grow to include information from other fisheries, and add new datasets to obtain a better view over global fisheries. The cloud environment will facilitate to have for-purpose maps, for instance for a subset of the ocean, and add maps of fishing effort and Essential Ocean Variables.

SDG 14.4.1 VRE; an integrated R Shiny Application

The SDG 14.4.1 VRE plays a key role in FAO support to the global community by offering web-based computational facilities with considerable processing resources to execute a specially-developed Stock Monitoring Tool (SMT) with R-shiny. The SMT can be used to run some methods of fish stock determination and thus to evaluate the sustainability of fish stocks. The VRE is used in FAO capacity development workshops as an operational e-training environment coupled with hands-on interactive session to test the SMT. The training allows users to develop their skills using sample datasets and use their own datasets with the tool.

[1] https://doi.org/10.5281/zenodo.3138920
[2] https://doi.org/10.5281/zenodo.2249305

The VRE is related to a wider overall FAO e-Learning module on SDG 14.4.1 that introduces basic fisheries concepts and definitions, illustrates some technical aspects of stock assessment and provides detailed guidance on the process and tools for the analysis and reporting of the Indicator.

The SDG 14.4.1 VRE is available to authorized users after the training, and is available to the global community upon request. It is a community-oriented, flexible, and secure working environment that was developed through a collaboration between FAO and CNR-ISTI. It is integrated in the D4Science e-Infrastructure (www.d4science.org) that is also used for Blue-Cloud. The infrastructure fosters collaboration between users and regulate users' access to data and services. Downloadable reports are automatically saved to the private workspace, enabling users to trace their tests, and create reproducible results.

Access to the SDG 14.4.1 VRE is now controlled; it is available to authorized users within the window of a few days prior to and after the training. However, is available to the general public upon request.

Global Record of Stock and Fisheries VRE; an on-line registry combining CKAN and semantic technologies

In an ever more data-dependent world national, regional and global institutions need the best available scientific evidence to ensure sustainable fisheries. The Global Record of Stock and Fisheries (GRSF) is the digital innovative public-private partnership offering data services in support of: 1) keeping a record of the state of stocks and fisheries for reporting on SDG indicators and 2) harmonizing public and private data on stocks and fisheries for seafood traceability, ecolabelling and food safety. Each stock and fishery reported through the SDG 14.4.1 process gets a unique identifier and all data that describe the area, management authority, and production that are needed for the monitoring of fish stocks and fisheries status are harmonized. GRSF identifiers enable a seamless data flow from data collection, through harmonization, to dissemination. The GRSF is both a collaboration and a global repository of stocks and fisheries resulting from collation and merging of records across (currently) three data sources; FAO Fisheries and Resources Monitoring System (FIRMS), Sustainable Fisheries Partnership, and University of Washington.

The GRSF is a FAO initiative and developed with H2020 funding. It is part of the iMarine Data Catalogue and is public data are accessible through a registry https://i-marine.d4science.org/web/grsf/data-catalogue, and a map-viewer https://i-marine.d4science.org/web/grsf/map-viewer.

H2020 Blue-Cloud will add more data-services to GRSF to add data from other domains, such as time series download (e.g. csv files of catch and effort data), Essential Ocean Variables from capture areas, or effort maps. The data will also be made available as Blue-Cloud Web services (APIs in JSON format).

The infrastructure; D4Science

The e-Infrastructure (www.d4science.org) for these VREs is operated by CNR-ISTI and also used for Blue-Cloud. It uses Liferay portals as the portlet-hosting platform, as a complete platform for building web apps, mobile apps, and web services. It is JSR 168 and JSR 286 compliant. These VREs can take various forms including web interactive user interface, web applications, and pluggable standalone user interface. There are different levels of user authorization: VRE Manager, VRE Designer, and VRE User.

General features that are shared by all VREs include a social networking collaboration platform to use the common facilities typical of social networks e.g., posting news, commenting on posted news of common interest. The community space allows users to interact both publicly and privately, and provides a sense of community between fisheries scientists worldwide. The VRE provides private and public workspaces where data and documents can be stored and shared. Every user can have up to 100 GB storage space. An important feature of the VRE is the interaction between the VRE and the private workspace.

Conclusion

FAO is committed to mobilizing technologies and services to support restoring overfished stocks to sustainable levels. VREs provide an online environment to the global fisheries science community with access to dedicated tools but with robust data policies.

The VRES can deliver innovation for communities that want to collaborate across domains to achieve the SDGs, and. FAO strives to expand the range of these VRE tools and services for the global SDG community.